ESTIMATION OF PEDESTRIAN LEVEL OF SERVICE FOR INDIAN ROADS

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ESTIMATION OF PEDESTRIAN LEVEL OF SERVICE FOR INDIAN ROADS

A thesis submitted in partial fulfillment of requirements for the degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

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NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008
2013

NATIONAL INSTITUTE OFTECHNOLOGY
ROURKELA – 769008

CERTIFICATE

This is to certify that project entitled "**Estimation of Pedestrian Level of Service for Indian Roads**" submitted by ***Sambhu Mohanty*** in partial fulfillment of the requirements for the award of **Bachelor Of Technology** Degree in **Civil Engineering** at National Institute of Technology, Rourkela is an authentic work carried out by him under my personal supervision and guidance. To the best of my knowledge the matter embodied in this project review report has not been submitted in any college/institute for awarding degree or diploma.

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ACKNOWLEDGEMENT

I would like to thank NIT Rourkela for giving me the opportunity to use their resources and work in such a challenging environment.

First and foremost I take this opportunity to express my deepest sense of gratitude to the guide PROF.PRASANTA KUMAR BHUYAN for his able guidance during the project work.

This project would not have been possible without his help and the valuable time that he has given amidst his busy schedule.

I would also like to extend my gratitude to PROF. NAGENDRA ROY, Head, Department of Civil Engineering, who has always encouraged and supported in doing my work.

Last but not the least I would like to thank all the staff members of Department of Civil Engineering who have been very cooperative with me.

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DEPARTMENT OF CIVIL ENGINEERING

NIT ROURKELA

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Abstract

Over the last decade there has been a steep rise in the volume of traffic in India. This has led to congested and jams packed roads. In order to avoid these situations, now a day the traffic engineers are designing vehicle oriented roads which has jeopardized the safety of pedestrian traffic in the highly populated urban areas.

The study aims at finding a walkable environment for pedestrians with minimum pedestrian-vehicle interaction. For this purpose it is essential to determine the LOS of the study area. The LOS is a measure to determine the compatibility of bicycles, pedestrians, vehicles etc. the HCM defines six PLOS levels namely LOS A, B, C, D, E, F. By determining the PLOS score of the area the LOS of the area was deduced.

In order to determine PLOS a set of qualitative data was collected by devising a questionnaire which was used to get the real time response of people in road environment. People of across all genders and age group participated in the survey. Most of the questions were rating based with some yes/no types and some were questions were based on with logical choices.

After segmenting the data it was analyzed by using inverse variance method. The pedestrian level of safety was determined and it was found out that the study area is an ideal location for pedestrians to travel as they perceive the area safe and find all the amenities in the road which would attract the people to walk.

Keywords : level of service, pedestrian, road, traffic, vehicle – pedestrian interaction, inverse variance

Chapter 1

Introduction

1.1 *General*

In the last decade India has witnessed a high growth rate which has led to the genesis of many megacities in the country thereby leading to a massive increase in traffic. The motor-vehicle industry is burgeoning with an annual production rate of 4.6 million vehicles. For this purpose there is a need to find and provide a safe and walk able environment for pedestrians.

There are many factors which affect the pedestrian level of service but broadly they can be divided into two categories i.e. physical infrastructure and operational features. The physical infrastructure encompasses sidewalks, landscaped buffers, parking lane, street widths etc and the operational feature include traffic volume and speed limits. In India the traffic collision is highest which implies that more thrust should be given so that further deterioration can be curbed. For this reason the level of service concept was introduced so that qualitatively we could measure the level of safety of pedestrians, bicyclists, motorists etc on roads.

As stated by Litman (2007) an improved pedestrian safety and a safer walkable environment will help the community in achieving the following:

- For non drivers the accessibility would improve.
- Cost of transportation will sharply reduce.

- The parking efficiency in the area would be greatly enhanced.
- There would be improvement in aesthetics.
- Reduction in land needed for road construction.
- Reduction in the level of pollution and it acts as a support for transit.

1.2 *Statement of the problem*

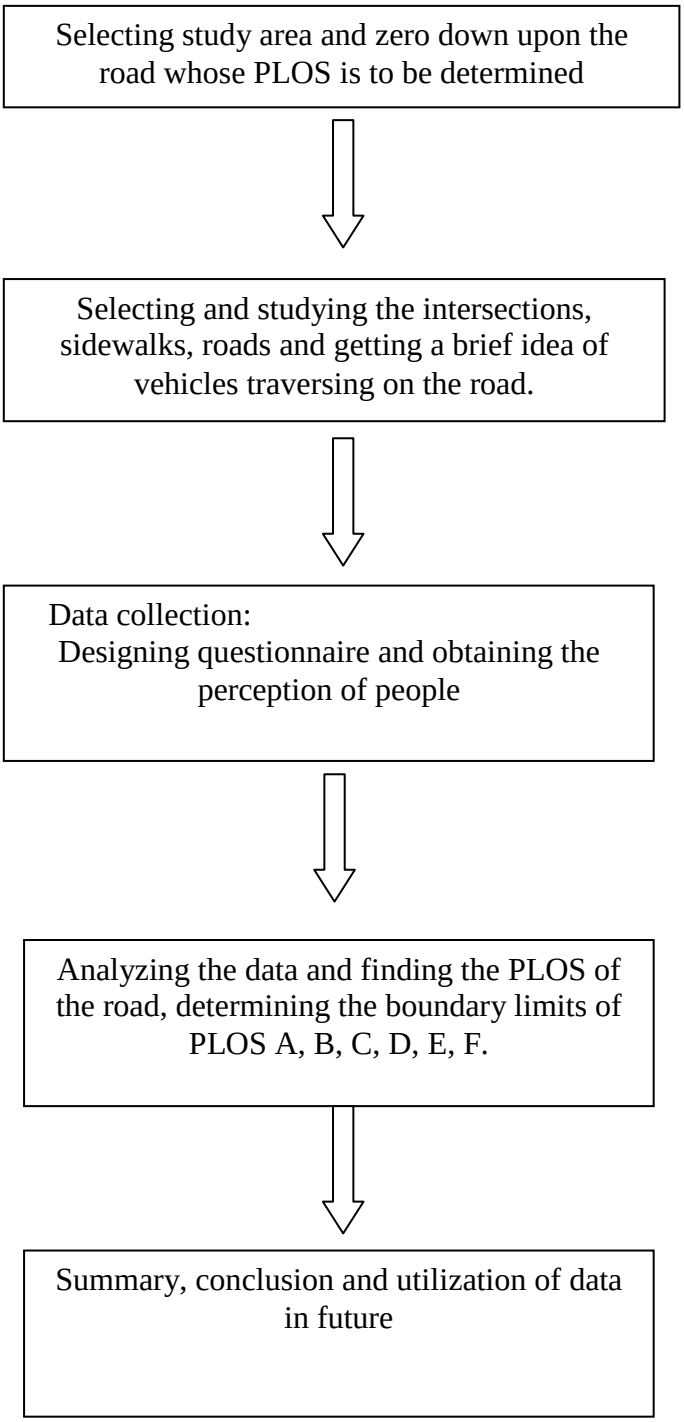
Rapid urbanization has taken its toll on pedestrian safety levels, often the traffic engineers in order to provide better transportation facilities either fail to provide pedestrian facilities on the roadside or compromise the safety of pedestrians. With the burgeoning traffic the lives of pedestrians is highly endangered. So the need of the hour is to provide a safe environment for pedestrians without any conflicts with other modes of transportation.

In order to determine the pedestrian level of service a questionnaire was designed and the real time perception of people was recorded on the sheet of questionnaire. In this way we could tap their real time stimuli based on their perception of traffic conditions they faced. They were asked very basic questions pertaining to the traffic conditions which were encompassed within the sections namely footpath, road, barrier, buffer, transit area, safety. They were asked to rate or say yes/no according to their perception as answers.

The perception of pedestrians will greatly be helpful in improving the walkable conditions for pedestrians in the area.

1.3 *Objective and scopes*

The study was aimed at improving the road conditions the result achieved by the research work will be helpful in designing roads in future which can guarantee enhanced safety for commuters. The overall framework of the project is depicted in fig 1



The main objectives are of the study are

- To provide higher safety to pedestrians without obstructing/hampering the inflow and outflow of traffic.
- To devise a yardstick for calming the traffic and to design the streets in such a way that it improves the pedestrian walking environment.
- Very little study has been carried out to perk up the pedestrian walking environment and the factors which define it.

1.4 *Organization of report*

The report consists of eight chapters. The first chapter provides an introduction to this research and elaborates upon the scopes and its objectives. The second chapter introduces us to the concept of Level of Service, how it came into existence and how it can be used to determine the quality of modern roads. In third chapter we get to know about different research works being carried out earlier. The fourth chapter deals with the study area it provides information about the details of the road and its characteristics and methodology applied for the analysis of data. It briefly describes about the inverse variance method. The sixth chapter deals with data collection, it contains the questionnaire designed to obtain the real time perception of people.

The sixth chapter showcases the result obtained after doing the rigorous analysis and contains bar-charts to quantitatively show the different perceptions of people based on their real time experience.

The seventh chapter provides the summary and conclusion to the thesis. The respective references to the authors are cited at the end whose works have been mentioned in the thesis.

Chapter 2

Concept of Level of Service for Pedestrians

2.1 *General*

The Level of Service is a yardstick used by traffic engineers to estimate the effectiveness of the elements of transportation infrastructure. LOS is most usually used to analyze highways by categorizing traffic flow width corresponding safe driving conditions. The level of service concept was first conceived for highways during the time of rapid expansion in the use and availability of the private motor car. The primary concern was congestion, and it was commonly thought that only the rapid expansion of the freeway network would curb congestion. The researchers proposed measurements of levels of service which would consider public transportation. Such systems would comprise of time to wait, frequency of service, time it consumes to pay fares, quality of the ride itself etc.

To meet the requirements of modern traffic engineer HCM defines six PLOS levels namely LOS A, B, C, D, E, F. LOS can also be applied to surface streets, to portray foremost signalized intersections. A jam-packed four-way intersection where the major traffic movements are conflicting turns might have an LOS of D or E. At intersections, queuing time can be used as a yardstick to measure LOS. By utilizing computer models and inputting full movement data we can get a good estimate of LOS. While it may be enticing to aim for an "A" Level of Service, this is impractical in urban areas. Urban areas usually adopt standards varying between "C" and "E", depending on

the area's size and characteristics, while "F" is sometimes permissible in areas with improved pedestrian, bicycle, or transit alternatives. More rigorous Level of Service standards (particularly in town/city areas) tend to dictate the widening of roads to accommodate development, thus discouraging use by these alternatives. Due to this, some planners advocate escalating population density in towns, narrowing streets, confining car use in some areas, providing sidewalks and safe pedestrian and bicycle facilities, and making the scenery fascinating for pedestrians. However due to some lacuna in the existing methodologies The National Cooperative Highway Research Program (NCHRP) is conducting a project to augment the methods to determine Levels of Service for automobile, transit, bicycle, and pedestrian modes on urban streets, with particular thrust given to intermodal interactions.

The pedestrian LOS ratings can be defined as a yardstick of pedestrian safety features & the level of automobile oriented development features along the roadways.

The pedestrian LOS levels are defined as follows:

LOS A: The roadways are highly pedestrian oriented & will tend to entice pedestrian trips. The roadways will be characterized by sufficient pavement space, pedestrian friendly intersection designs, low speed or low-volume motor-vehicle traffic, and bountiful facilities (e.g., shade, benches, and so forth). The roadway and sidewalk features will be planned at human scale for utmost pedestrian comfort. Roadways with this level of pedestrian accommodation may be expected in central-city, tourist, and college campus locations. Pedestrians can expect a low level of interaction with motor vehicles.

LOS B: These roadways provide many pedestrian safeties and comfort features that will draw pedestrian trips .These roadways would have many of the features of an LOS A pedestrian facility, but there may be somewhat fewer facilities or pedestrian-friendly design rudiments. Pedestrians can expect a low to moderate level of interaction with motor vehicles.

LOS C : These roadways are sufficient for pedestrian use, but may not necessarily attract pedestrian trips. These roadways will provide a standard sidewalk, but will likely have some short-comings in maintenance or intersection design, may be situated on roadways with high-speed, high volume motor-vehicle traffic, or there may be a sidewalk on one side of the street only. Pedestrians can expect moderate interaction with motor vehicles on these roadways.

LOS D: These roadways are sufficient for pedestrian use, but will not draw the attention of pedestrian for commuting. These roadways will have more recurrent deficiencies in pedestrian safety and comfort features and are more likely to infringe requirements for width and clearance. Gaps in the sidewalk system may occur within this roadway corridor. Intersection crossings are likely to be more frequent and more hard. Pedestrians can anticipate moderate to high levels of interaction with motor vehicles.

LOS E: These roadways are not suitable for pedestrian use. These roadways may or may not provide a pedestrian facility. Even where a sidewalk is provided these roadways will not meet the requirements and will have frequent deficiencies in sidewalk width, clearance, continuity, and intersection design. Roadways in this category that do not provide a pedestrian facility may be characterized in border areas of cities, rural section

roadways with lower motor-vehicle traffic. Pedestrians can anticipate a high level of interaction with motor vehicles.

LOS F: These roadways hardly provide any uninterrupted pedestrian facilities and are characterized by high levels of motor vehicle use and automobile-inclined development. These roadways are designed primarily for high-volume motor-vehicle traffic with frequent turning conflicts and high speeds.

2.2 *Factors affecting Pedestrian Level of Service*

The factors affecting level of service can be summarized as follows:

1. Traffic volume: We would observe that as the traffic volume increases the PLOS consequently tends to decrease. One can easily observe that during heavy traffic the pedestrians are more apprehensive of their safety than other time.
2. On street parking: this factor has a positive influence on PLOS as it acts as a buffer in between the traffic and the pedestrian thus providing a sense of security. As the people perceive they are safe, hence it results in higher LOS.
3. Sidewalk width : greater the width of sidewalk greater is the level of safety being perceived by pedestrians as they feel more comfortable which results in a higher PLOS.
4. Roadway width : with increase in width of road the pedestrian feels it more difficult to cross the road from one end to another thereby decreasing the PLOS. Normally now a days in order to accommodate the traffic we find carriage ways of large widths resulting in a lower PLOS.

5. Speed limits : The speed limit for the road surveyed was 40 km/hr. with increase in speed there is a drastic decrease in the pedestrian level of service. It is due to the fact that at higher speeds the pedestrians perceive higher threat levels to their life hence resulting in a decrease in PLOS.
6. Number of lanes : With increase in number of lanes there's a increase in the total width of the road hence there is greater probability of pedestrian-vehicle interaction which leads to lower safety levels and hence it leads to lower PLOS score.

Chapter 3

Review of Literature

3.1 *General*

The purpose of this chapter is to review the literature of the traffic characteristics which affect the pedestrian real time stimuli. In order to determine pedestrian level of service the speed at which a pedestrian traverses is probably the most imperative characteristic of a pedestrian facility which is affected by the specific pedestrian characteristics and habit. Many researchers like Fruin thought that pedestrian planning and design is the basis of current pedestrian LOS methodology.

Fruin et al (1971) stated that "pedestrian service standards should be based on the freedom to select normal locomotion speed, the ability to bypass slow-moving pedestrians, and the relative ease of cross- and reverse-flow movements at various pedestrian traffic concentrations." He also found that design standards are not same across all environments and that his level of service guidelines is, ultimately, subjective, though based on a great deal of experimental evidence. More interestingly for the purposes of this study, Fruin has found that "people require a lateral space of 28 to 30 inches…for comfortable movement. The longitudinal spacing for walking…would be 8 to 10 feet. This results in a minimum personal area of 20 to30 ft2/person for relatively unimpeded walking in groups on level surfaces."

Pushkarev and Zupan et al(1975) found out that flow rate and speed are closely related. They found out that "people, or vehicles, are likely to move at a faster

speed if the flow rate is low." They said "the exact effect of the various obstacles on pedestrian capacity and flow is a good subject for further study; paths could be traced with time-lapse photography…each obstacle leaves an unused sidewalk area in its 'wake' in the pedestrian stream."

Gregory Benz et al (1986) challenged the existing LOS calculations and found a method best suited for transportation terminals and other complex pedestrian spaces which could be applied to sidewalks, as well. His methodology is called the time-space approach. In time-space approach, pedestrian activities generate time-space needs. The areas where these activities take place are time-space zones and they have limited capacity to meet pedestrian time-space needs.

. In his paper Mozer et al (1994) introduces a measurement called the "walk area width volume" (WWV) for pedestrians. The WWV is determined by using an equation which includes measures of peak hour pedestrian volumes, mode split that is not pedestrian (wheelchairs, bicyclists, skaters, runners, etc.), usable width of the walk area, and a "travel pattern factor" representing the one way or bi-directional nature of the facility's pedestrian traffic.

. The most important concept in the Milazzo (1999) *et al.* article in terms of this study is the authors' suggestion that congregation in specific locations such as airport terminals is more common and thus more expected than it is on normal everyday walkways. They introduce the idea of "transportation terminals," in which LOS calculations for congregation are adjusted to reflect the special nature of certain walkway facilities. The LOS rating is relative to the expectation of congregation on particular walkways.

Venkata Chilukuri et al (2000) challenged the current equation used by the HCM to calculate pedestrian delay at signalized intersections. Chilukuri's statistical analysis of high and low flow rates on sidewalks between signalized intersections indicated that the arrival of pedestrians at those intersections had a significantly non-random pattern. In addition, it is found that, in a coordinated signal network (such as those which exist in large urban areas), "pedestrians arriving randomly at an intersection will move in a group after the signal turns green and might continue as a significant group towards the downstream signal." randomly at an intersection will move in a group after the signal turns green and might continue as a significant group towards the downstream signal."

Muraleetharan Thambiah, Takeo Adachi, Toru Hagiwara, Seiichi Kagaya, and Ken'etsu Uchida et al(2004) proposed to re-configure the calculation of pedestrian levels of service using a statistical method. In their study, the conjoint analysis technique was used to determine how pedestrians prioritize the attributes of sidewalks and how different levels of the above factors (or attributes) affect their perceived level of service on a sidewalk.

According to Young-In Kwon, Shigeru Morichi, and Tetsuo Yai et al (1989) "the occupancy index could be applied for the design of planned streets and the evaluation of street, space improvements…considering not only traffic flow but also the physical size of traffic modes and the time needed to traverse the street." They also suggest that the occupancy concept be applied to the LOS measurement procedure for streets with "mixed traffic" modes, i.e. streets which are so narrow that pedestrians

sometimes walk in automobile and bicycle lanes. This seems to be a useful measure for planning particularly narrow, busy streets with limited roadbed.

Serge P. Hoogendoorn et al (2003) found that pedestrians are motivated by cost minimization. Pedestrians act according to predictions on other pedestrians' experience, but they have a limited predictive ability. Walking too close to other pedestrians and obstacles has a cost for a pedestrian: the "proximity discomfort" or "proximity cost". Accelerating and deviating from the planned path have also a cost for a pedestrian. Another hypothesis by the author is that walkers avoid proximity to groups of pedestrians more than to a single pedestrian, because it is assumed that proximity costs are additive.

The Turner-Fairbank Highway Research Center report found out that while calculating walking speed for crosswalks, the report suggests, the speed should be expected to be lower where "large numbers of older pedestrians" are present. In defining "large numbers," the report suggests that "large numbers of older pedestrians exist when the elderly proportion begins to materially affect the *overall* speed distribution at the facility." In this case, a material effect on the overall speed distribution occurs when the percentage of elderly using a crosswalk facility exceeds 20 percent.

3.2 *Summary*

A thorough literature review was carried out to understand the concept of Pedestrian Level of Service, factors that affect the Level of Service like sidewalks, condition of roads, speed of vehicle etc. from literature review it was found that there are a lot of limitations in recent LOS methodology as prescribed by HCM.

Chapter 4

Methodology and Study Area

4.1 *General*

The key step by step procedures for applying methodology for determining performance measures and level of service for the study area are

- Selecting a tool for analysis.
- Facility segmentation.
- Gathering qualitative data by questionnaire
- To measure or forecast performance of pedestrians.
- Calculating pedestrian LOS

A linear relationship was framed in between the PLOS and the data obtained from the questionnaire. The relationship was formulated as follows

$$y = aX_1 + bX_2 + cX_3 + dX_4 + eX_5 + fX_6$$

Here in the linear relationship the coefficients were determined by **inverse variance** method. The coefficient ***a*** stood for the sidewalk/pavement conditions, ***b*** represented road characteristics, ***c*** represented the interaction of pedestrian mode with other mode of transportation at intersections, ***d*** considered the effect of buffer on PLOS, ***e*** represented the transit area and ***f*** represented the coefficient for safety.

The value of X_1 ,X_2 ,X_3 ,X_4 ,X_5 ,X_6 was determined by averaging the whole rating obtained for the respective cluster.

In order to determine the limits of PLOS the best and worst conditions were chosen and the respective y_{max} & y_{min} was obtained. From this the difference between the y_{max} & y_{min} was determined and they were divided by the number of intervals to be obtained.

Next starting from minimum by consecutively adding the interval we obtain the boundary limits of the respective LOS. By comparing the value found i.e. y, we can estimate the PLOS of the road.

The questionnaire used to obtain the data is showcased in the next page.

QUESTIONNAIRE

NAME –
AGE –
SEX –
TIME –

1. FOOTPATH

- Is the width of footpath enough for you?(rate it 1-5)
- How do you like to travel (in group/single)?
- How would you rate the surrounding and cleanliness of the area?(rate it 1-5)
- Is the footpath continuous on both sides? (yes/no)
- Is there proper lighting during night to have a clear view of footpath? (rate it 1-5)

2. ROAD

- Do you feel comfortable with the width of road while crossing?(rate it 1-5)
- How would you rate the vehicular traffic speed? (rate it 1-5)
- Is median present? (yes/no)
- Is the median width suitable for you to stand? (rate it 1-5)
- In terms of safety how would you rate the width of road? (rate it 1-5)
- Do you think specifying a speed limit for the road will make it safer? (yes/no)
- How comfortable do you feel when the following vehicles approach while crossing (please provide ratings) -:
    i. When a heavy vehicle like bus/truck is approaching.
    ii. When lighter vehicle like car approaches.
    iii. When a bicycle/bike approaches.

3. CROSSINGS /INTERSECTIONS

- Do the vehicles pose a threat for you while turning? (yes/no)
- Does the road have any provision for zebra crossing? (yes/no)
- While crossing or turning are you able to clearly see the approaching vehicles? (yes/no)
- Are there speed bumps before crossings i.e. zebra crossings?
- In which type of turnings i.e. sharp/curved at intersections you feel safer, rate it.
- How convenient you feel while crossing the road (with respect to traffic volume)? (Rate it 1-5)

4. BARRIER /BUFFER

- Is there any barrier in between road and pedestrian network? (yes/no)
- Will you feel safer to walk on the pavement if barrier is provided to separate vehicular traffic and pedestrian network? (yes/no)

5. TRANSIT AREA

- Can you view the bus stop clearly? (rate it 1-5)
- Is the sight distance to bus stop adequate for you? (rate it 1-5)

6. SAFETY

- In terms of safety how do you perceive the area? (Rate it 1-5)
- According to you do you feel that drivers are following driving rules and regulations? (yes/no)
- Rate the space between pavement and vehicular traffic in terms of how comfortable you feel.
- In terms of accident frequency, rate the road.

Study Area

4.3 *Introduction*

For the research project sector-2 bus stand junction of Rourkela city was considered as the study area. A Google map image is shown in fig 2

The presence of intersections and the higher traffic volume makes it an interesting and challenging area to carry out the survey work. The questionnaires were distributed among the people at the location and asked to fill out the forms immediately to collect the data.

Chapter 5

Data collection

5.1 *General*

In order to obtain the qualitative data rigorous literature review was carried out to zero down upon some factors which greatly affect the PLOS.

The variables in the determination of PLOS are as follows:

The presence and condition of pavement/sidewalks was given huge importance, key considerations with the variables include is the sidewalk present/absent?, is sidewalk continuous? Etc.

Traffic volume greatly affected the comfort level of pedestrians with low traffic volume the pedestrians perceived more relaxed and safe. With increase in number of vehicles the conflict between pedestrians and traffic greatly gets enhanced.

The buffer between vehicular and pedestrian traffic improved pedestrian LOS. The on street parking also acts as a good barrier thus helping to improve the PLOS.

On lower posted speed limits the speed didn't have a great effect on PLOS, as speed increased beyond the posted speed limit greatly influences the PLOS. The posted speed limits are also helpful for safety audits and analyses.

The greater the number of lanes greater is the chance of a potential conflict between pedestrians and the vehicular traffic. So for a pedestrian it is more comfortable to cross a narrow street rather than a wider one.

On the basis of these principles the questionnaire was designed.

About 100 people participated in the survey. The survey was carried out at different time of the day to observe the effect of traffic during rush hours and also during dull hours. The people from all age groups were asked to jot down their perception on the paper.

The questions were properly explained and then they were asked to write their view points. The whole questionnaire comprised of different questions aimed at studying their effects on the outcome of PLOS. The questions were rating and logical based in order to explore and record the real time response of people when they are subjected to those situations. The data sheet is displayed below(table 1).

NAME	AGE	GENDER	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7
rajendra appat	55	male	2	single	3	yes	3	3	2	yes	3	2	yes	1,4,5
saubhgya mohapt	17	male	3	single	5	no	4	2	4	no	5	4	yes	4,4,5
a.k paramanik	22	male	5	grp	5	yes	5	1	2	no	2	1	yes	3,4,5
s.p das	50	male	2	grp	2	yes	3	1	5	yes	1	1	no	1,1,1
b.singh	19	male	4	single	3	yes	3	3	3	yes	3	3	yes	2,3,3
s sharma	21	male	4	grp	3	no	3	2	4	yes	5	4	yes	1,3,4
r.k das	18	male	1	single	1	no	5	1	1	yes	4	5	yes	2,4,5
s nayak	24	male	3	grp	4	no	3	3	4	no	3	4	no	3,4,5
c nayak	39	male	5	single	4	yes	5	4	5	yes	4	5	yes	2,3,5
s.c nayak	58	male	3	single	4	yes	1	5	1	no	5	5	yes	2,3,1
t bagh	39	male	3	single	3	yes	4	3	4	no	4	3	no	2,4,4
l d das	51	male	2	grp	3	no	2	5	5	yes	4	4	yes	2,3,3
d tudu	27	male	3	grp	5	yes	5	4	3	no	5	5	yes	2,4,5
s das	22	female	3	single	3	no	2	3	2	no	3	4	no	2,3,5
g sagar	32	male	4	grp	1	yes	2	4	4	no	3	4	no	3,4,2
a jena	25	male	2	grp	4	yes	3	4	3	yes	3	3	yes	1,4,5
s dash	19	female	3	grp	3	no	1	1	3	yes	1	2	yes	1,1,5
s sahoo	19	female	3	grp	3	no	1	1	3	yes	1	2	yes	1,,2,3
l p teli	19	female	3	grp	3	yes	1	1	3	yes	2	3	yes	1,4,4
h parida	29	male	1	single	5	yes	1	3	3	yes	3	4	yes	2,5,5
s maharana	29	male	1	single	1	yes	3	1	3	yes	3	2	yes	1,3,4
p k patra	42	male	5	grp	5	yes	1	5	4	yes	5	3	yes	5,5,3
s r mishra	27	male	4	grp	5	yes	4	5	3	yes	5	3	yes	1,4,5
p l sahoo	27	male	4	grp	2	yes	3	4	3	yes	4	3	yes	2,3,5
d mohanty	27	male	5	grp	4	yes	3	3	4	yes	3	3	yes	1,2,4
s sahoo	27	female	2	grp	2	yes	1	4	3	no	4	3	yes	1,,3,5
s john	34	male	2	grp	3	no	2	4	3	yes	2	4	yes	3,3,4
d dash	39	male	2	grp	1	yes	1	1	1	yes	1	2	yes	1,2,3
m s das	28	male	2	grp	2	no	1	1	1	yes	1	1	yes	1,3,5
r swain	16	female	2	grp	5	yes	4	5	3	yes	5	4	yes	1,5,5
a pradhan	16	female	3	grp	5	no	3	3	3	yes	3	3	yes	1,5,4
k sha	17	female	3	grp	5	yes	4	5	3	yes	5	4	yes	1,1,5
s r samal	17	female	3	grp	5	yes	4	5	3	yes	4	5	yes	2,2,4
j rout	18	female	3	grp	5	yes	4	5	3	yes	5	4	yes	1,1,5
m tripathy	16	female	4	grp	3	yes	3	3	4	yes	4	5	no	2,2,4
k pradhan	21	female	3	single	3	no	4	4	3	yes	3	4	yes	2,3,4
a soreng	18	male	2	grp	1	no	2	2	1	no	3	2	yes	2,4,4
n hembram	20	male	1	grp	1	no	1	3	3	yes	1	4	yes	1,3,5
b k bariganjan	36	male	3	single	3	yes	2	1	3	yes	3	3	yes	1,1,4
s k nayak	13	male	4	single	2	yes	3	5	3	no	2	4	no	1,3,5
s k minz	12	male	3	single	2	yes	3	2	3	no	3	3	no	4,5,5
s nanda	13	male	4	single	2	yes	3	4	4	yes	1	3	no	1,2,5
k mahanta	25	male	2	single	2	no	3	2	3	yes	2	2	no	3,4,5
b kar	47	female	3	grp	5	yes	5	3	4	yes	5	5	yes	2,2,3
b bhol	30	male	4	single	4	no	3	4	2	no	4	3	no	1,1,5
g pravakar	14	male	3	grp	3	yes	1	5	3	no	4	5	yes	1,1,3
h s das	40	male	2	single	1	no	1	1	3	no	1	1	yes	1,2,2
b b swain	51	male	1	grp	2	yes	2	3	4	yes	5	2	no	2,2,4
a sahoo	38	male	2	single	4	no	4	5	2	yes	3	1	yes	1,1,3
pratik rout	28	male	2	single	3	no	5	3	3	yes	3	3	no	3,2,3

NAME	3.1	3.2	3.3	3.4	3.5	3.6	4.1	4.2	5.1	5.2	6.1	6.2	6.3	6.4
rajendra appat	yes	yes	no	no	curve	3	no	no	4	2	3	no	4	2
saubhgya mohapt	yes	yes	yes	no	curve/5	5	yes	yes	1	4	5	no	3	5
a.k paramanik	yes	yes	yes	yes	curve	5	yes	yes	1	1	2	no	1	2
s.p das	yes	yes	no	no	curve/2	1	no	yes	3	4	2	no	5	5
b.singh	yes	yes	yes	yes	curve/4	3	yes	no	5	3	3	yes	4	3
s sharma	no	yes	no	yes	curve/3	3	no	no	4	3	3	no	3	3
r.k das	no	yes	yes	no	curve/1	1	yes	yes	1	1	5	yes	1	2
s nayak	no	no	no	yes	curve/4	4	no	yes	4	4	4	yes	4	2
c nayak	yes	yes	yes	yes	curve/3	2	yes	no	5	4	1	yes	3	4
s.c nayak	yes	no	yes	yes	curve/2	2	no	yes	2	2	1	no	3	1
t bagh	no	yes	no	yes	curve/4	2	yes	yes	3	4	2	yes	3	3
l d das	no	yes	yes	no	curve/3	3	no	yes	2	2	2	yes	3	4
d tudu	no	yes	yes	yes	curve/4	3	no	yes	5	4	4	yes	3	2
s das	yes	yes	yes	no	curve/2	2	no	yes	2	3	3	yes	4	3
g sagar	yes	yes	yes	yes	curve/3	4	yes	yes	4	4	4	yes	2	4
a jena	no	yes	yes	no	3	2	no	yes	3	4	2	yes	3	1
s dash	yes	yes	yes	no	3	2	yes	no	1	5	2	no	2	5
s sahoo	no	yes	no	yes	1	4	no	yes	4	5	4	yes	3	4
l p teli	no	no	yes	yes	2	5	no	yes	3	4	1	no	5	2
h parida	yes	no	yes	no	5	2	yes	no	2	3	5	yes	3	4
s maharana	yes	yes	no	no	2	2	no	yes	1	3	3	yes	1	1
p k patra	yes	no	no	no	5	5	no	yes	1	4	2	no	2	2
s r mishra	yes	yes	yes	no	1	3	yes	yes	4	4	4	no	3	5
p l sahoo	yes	yes	yes	yes	4	4	no	yes	1	5	3	yes	4	4
d mohanty	no	no	yes	no	2	3	no	yes	3	3	3	no	3	3
s sahoo	no	yes	yes	no	3	3	no	yes	3	5	4	yes	4	5
s john	no	yes	yes	yes	sharp/2	4	yes	yes	4	4	3	no	3	3
d dash	yes	no	no	no	3	2	no	yes	2	4	1	no	2	2
m s das	yes	no	no	no	4	1	no	yes	4	2	1	no	2	1
r swain	no	no	yes	no	4	5	no	yes	5	3	3	yes	4	5
a pradhan	no	no	yes	yes	5	3	no	yes	5	4	5	yes	3	2
k sha	yes	no	yes	no	1	2	no	yes	5	3	3	no	2	3
s r samal	yes	no	yes	no	4	5	no	no	5	2	2	yes	4	3
j rout	no	no	yes	no	4	5	no	no	5	3	2	no	2	1
m tripathy	no	no	yes	yes	3	4	no	no	4	1	3	yes	4	3
k pradhan	yes	yes	yes	yes	2	5	no	yes	3	2	4	no	1	4
a soreng	yes	no	yes	no	2	2	no	no	3	3	2	no	2	2
n hembram	yes	no	yes	no	3	3	no	yes	5	3	4	no	3	3
b k bariganjan	yes	yes	no	no	2	5	no	yes	2	3	1	yes	4	5
s k nayak	yes	no	yes	no	3	2	yes	no	3	2	4	yes	1	4
s k minz	no	no	no	yes	3	2	yes	no	2	3	4	no	3	2
s nanda	yes	no	yes	yes	1	4	yes	yes	4	2	3	yes	3	2
k mahanta	yes	yes	no	yes	2	3	yes	yes	2	3	2	no	3	5
b kar	no	yes	yes	no	5	4	no	yes	1	5	1	yes	5	1
b bhol	no	no	yes	no	3	1	no	yes	4	3	2	yes	4	5
g pravakar	yes	yes	yes	yes	2	4	yes	yes	3	1	4	yes	4	2
h s das	no	yes	no	yes	2	5	no	no	3	4	1	no	1	5
b b swain	yes	yes	yes	no	1	3	yes	yes	1	1	5	yes	3	4
a sahoo	yes	no	no	no	3	1	yes	no	4	5	1	yes	2	1
pratik rout	yes	yes	yes	yes	sharp/2	3	no	yes	2	3	3	yes	3	3

Chapter 6

Results and Analysis

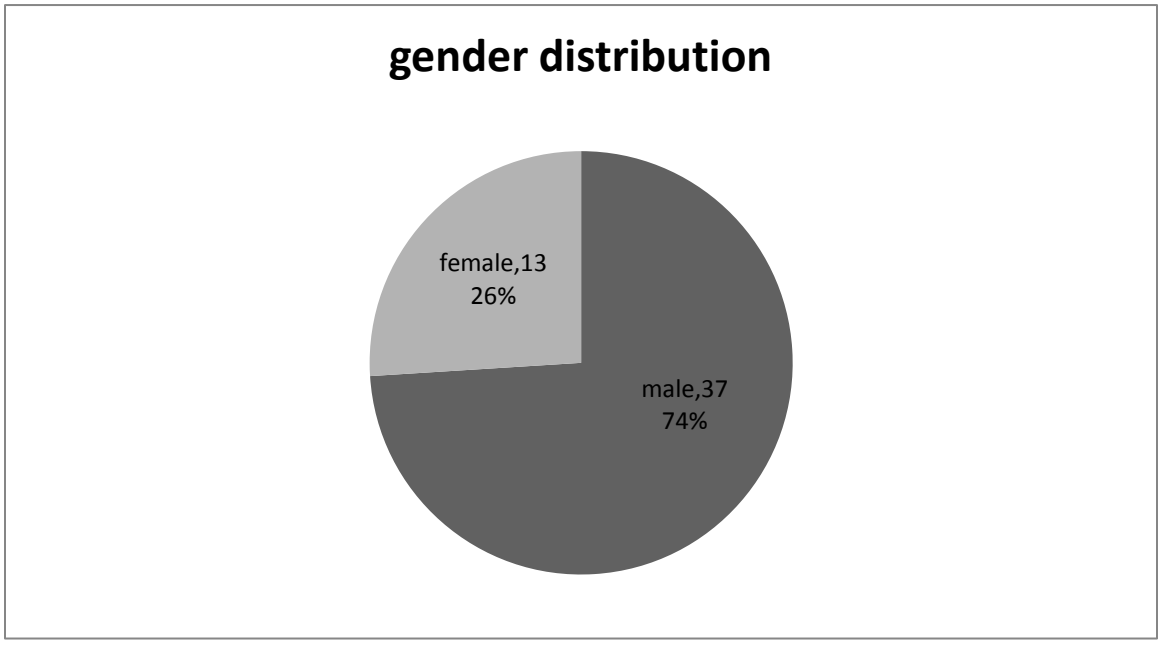
6.1 *Introduction*

After analyzing by using inverse variance method the results were obtained. From the data the PLOS of the road was determined by suitably determining the range of each LOS. The result obtained can be utilized by a traffic engineer to improve upon the present roads and a better walkable environment can be provided to the pedestrians in future by adopting suitable design methods for the road.

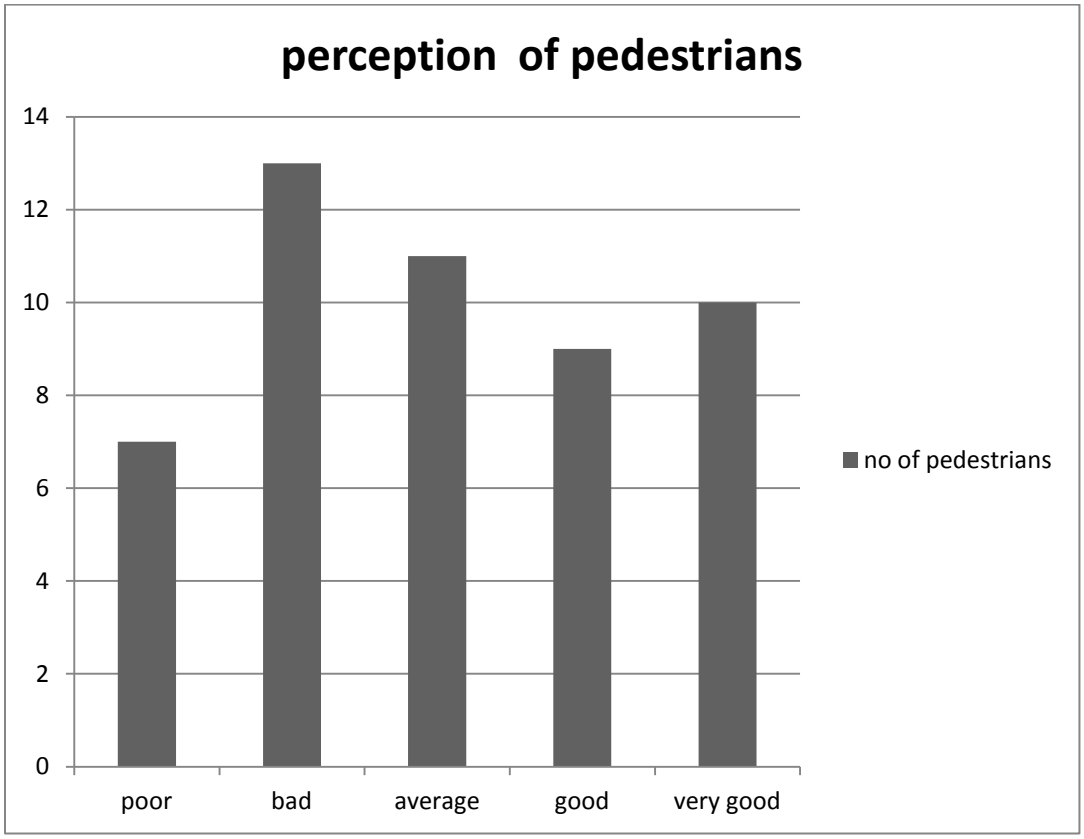
6.2 *Analysis of pedestrian perception*

In this section quantitatively the perception of people is shown in the form of bar charts for some earmarked questions.

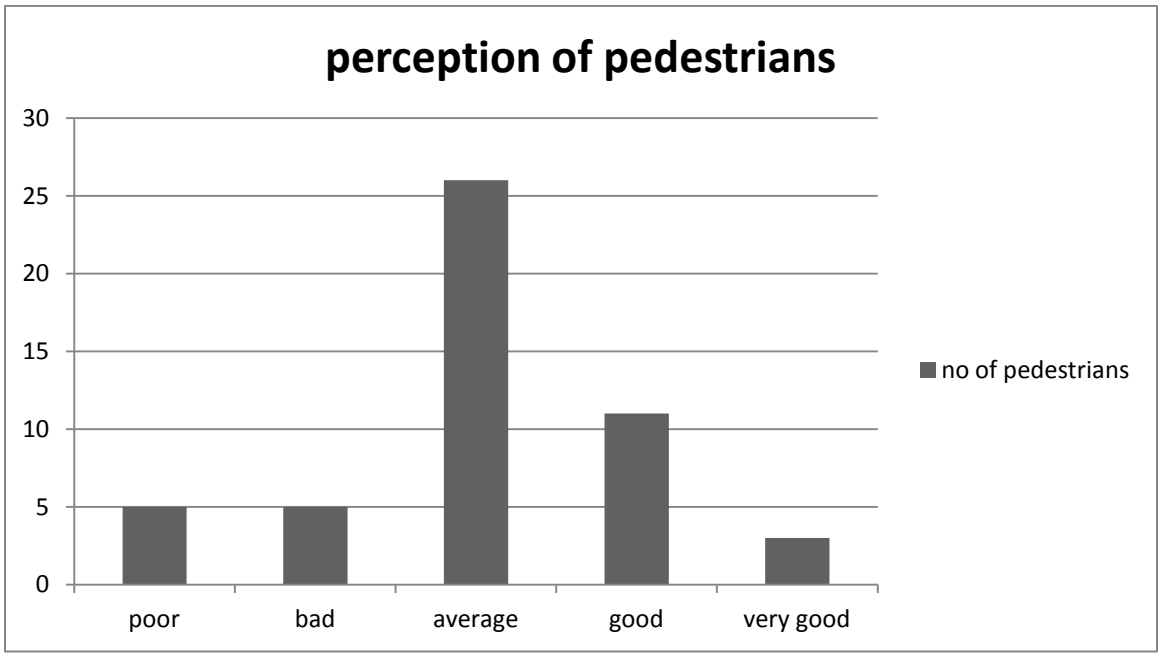
The gender distribution (graph 1)



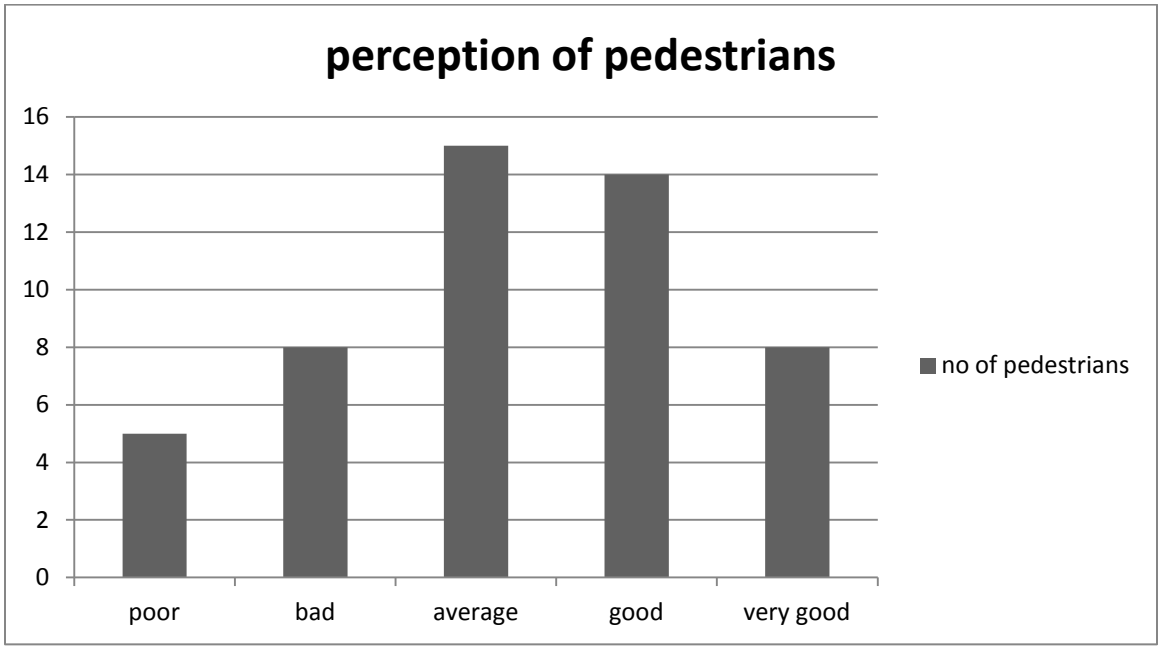
Q. ***Do you feel comfortable with the width of road*** while ***crossing?*** (Graph 2)



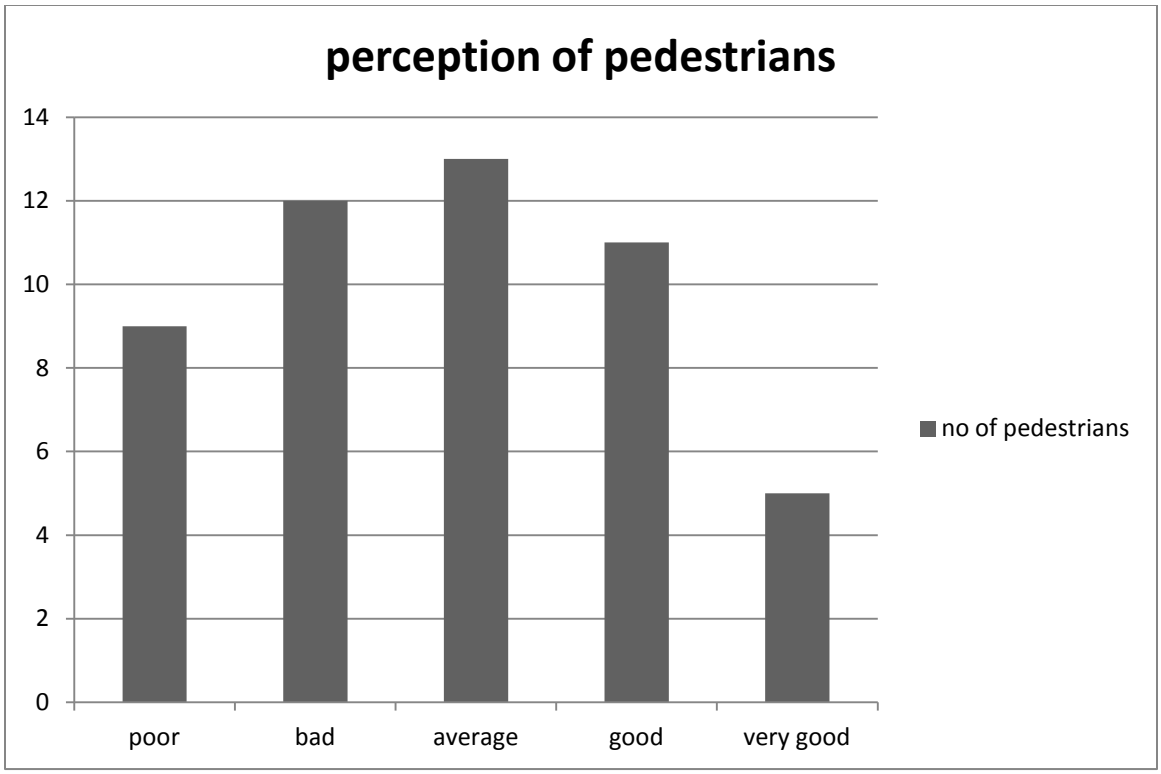
Q – How would you rate traffic vehicular speed? (Graph 3)



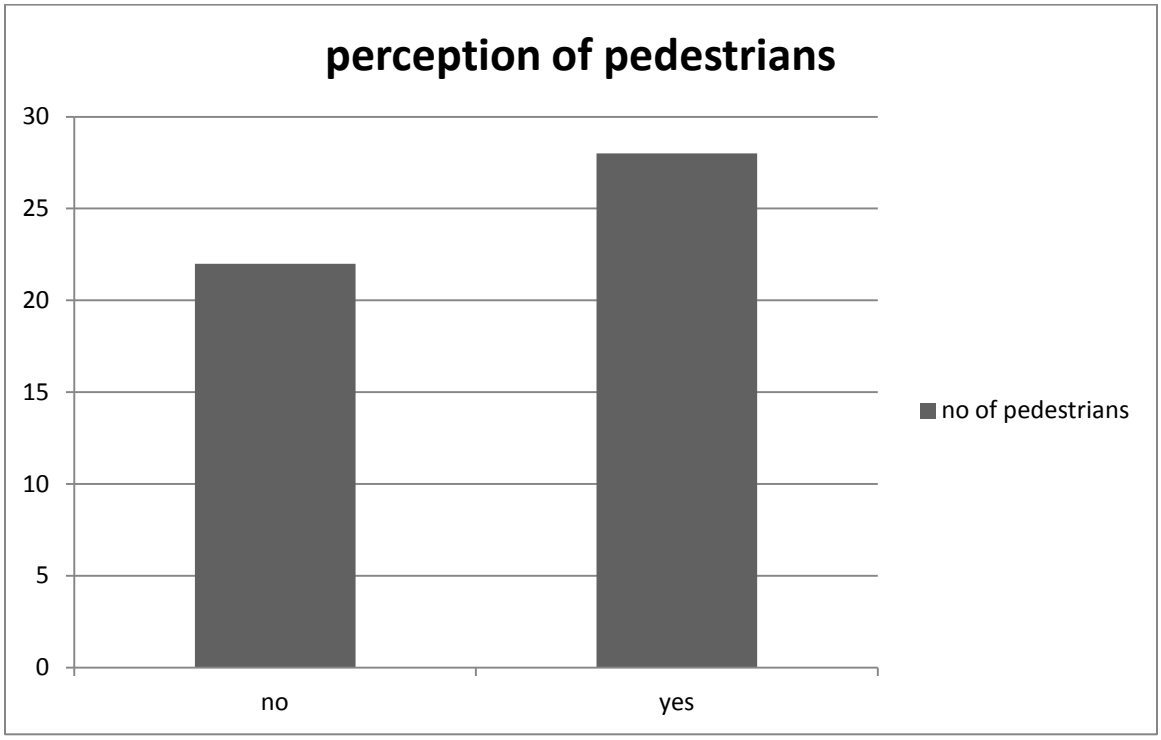
Q – In terms of safety how would you rate the road? (Graph 4)



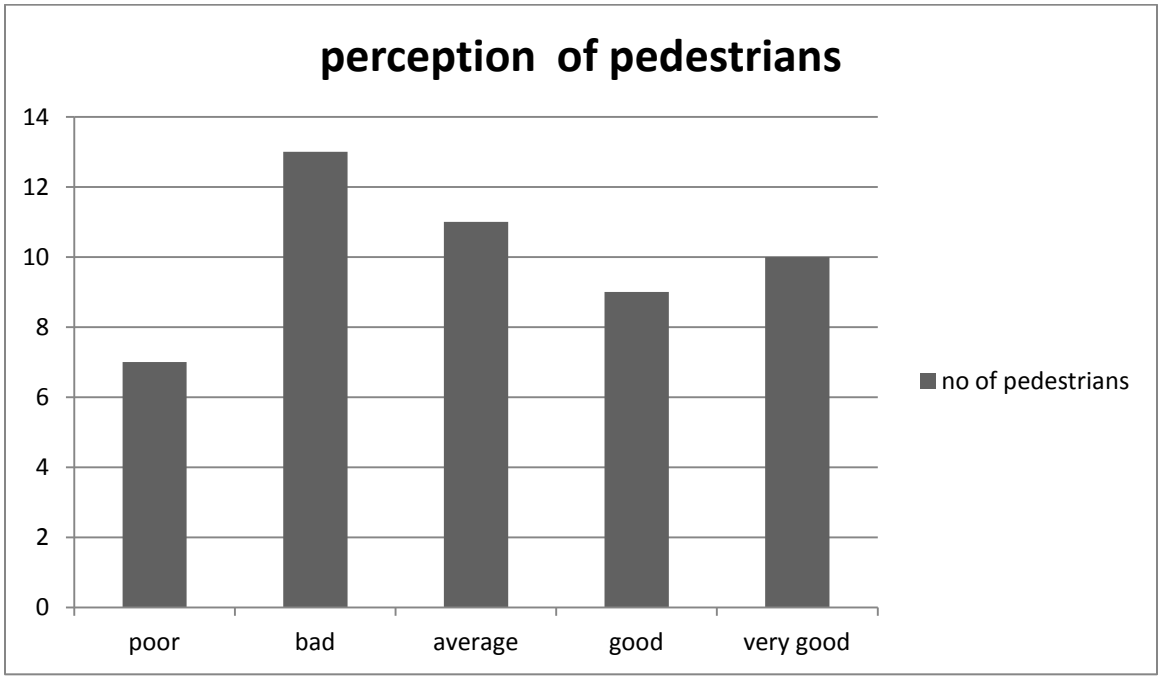
Q – In terms of safety how do you perceive the area? (Graph 5)



Q – According to you are the drivers following rules and regulations? (Graph 5)



Q – In terms of accident frequency, rate the road? (Graph 6)



The various factors obtained are displayed in the table below

constants	parameters	variance	inverse variance
a	footpath	2.234836	0.447460143
b	road	2.311634	0.432594419
c	crossings	1.939886	0.515494282
d	barrier	0.252137	3.966101695
e	transit area	1.562292	0.640085308
f	safety	2.205319	0.453449108

Table-2

The PLOS value obtained from the data

pedestrian level of safety(y)	**=**	**7.805323943**
pedestrian level of safety(y_{max})	=	17.33807018
pedestrian level of safety(y_{min})	=	7.518317806
interval	=	1.636625395

The mean of all the data obtained for all factors
(Table 3)

X	mean
X1 =	2.372881
X2 =	2.508475
X3 =	1.372881
X4 =	0.5
X5 =	3.042373
X6 =	2.25

The PLOS score and defining the ranges of different level of service (Table 4)

LOS	PLOS RANGE		
A	7.518318	TO	9.154943
B	9.154943	TO	10.79157
C	10.79157	TO	12.42819
D	12.42819	TO	14.06482
E	14.06482	TO	15.70144
F	15.70144	TO	17.33807

Chapter 7

Summary and Conclusion

7.1 *Summary*

This study was carried out the find the PLOS qualitatively. The qualitative method is a better method to determine PLOS as it inputs the real time response of people thus providing an option of achieving a better and more accurate result. the data was analyzed by using inverse variance method and the PLOS score table was obtained by determining the ranges for each level of service which helped in the estimation of the PLOS of the study area.

7.2 *Conclusions*

After analyzing the data we arrive at following conclusions:

- The PLOS score obtained by inverse variance analysis was found out to be 7.81 which is within the range of LOS A i.e. in between ***7.518 & 9.153.*** This signifies that PLOS of the road segments in the study area are providing best quality of service A to the pedestrians in the prevailing geometry and surrounding environmental characteristics. The study area is highly compatible for pedestrians as it guarantees the highest perceived safety levels as well.
- It is also found out that the area contains all facilities which will attract pedestrian trips.

- The LOS A signifies that the condition of sidewalk, road characteristics are of high standards and the pedestrian-vehicle interaction is minimum within the study area.
- The area contains sidewalks on both sides and has only two carriageways on each road segment and the effective volume of traffic is low, so for these reasons the PLOS perceived in this study area is A.

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